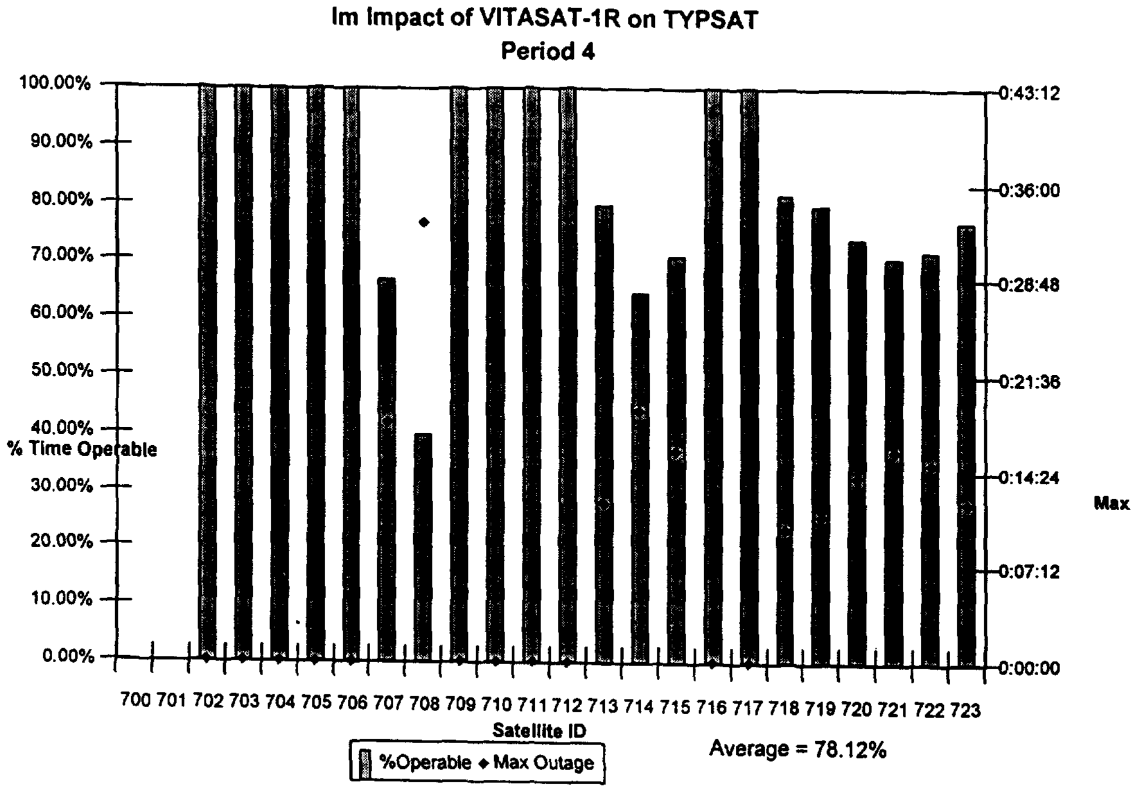
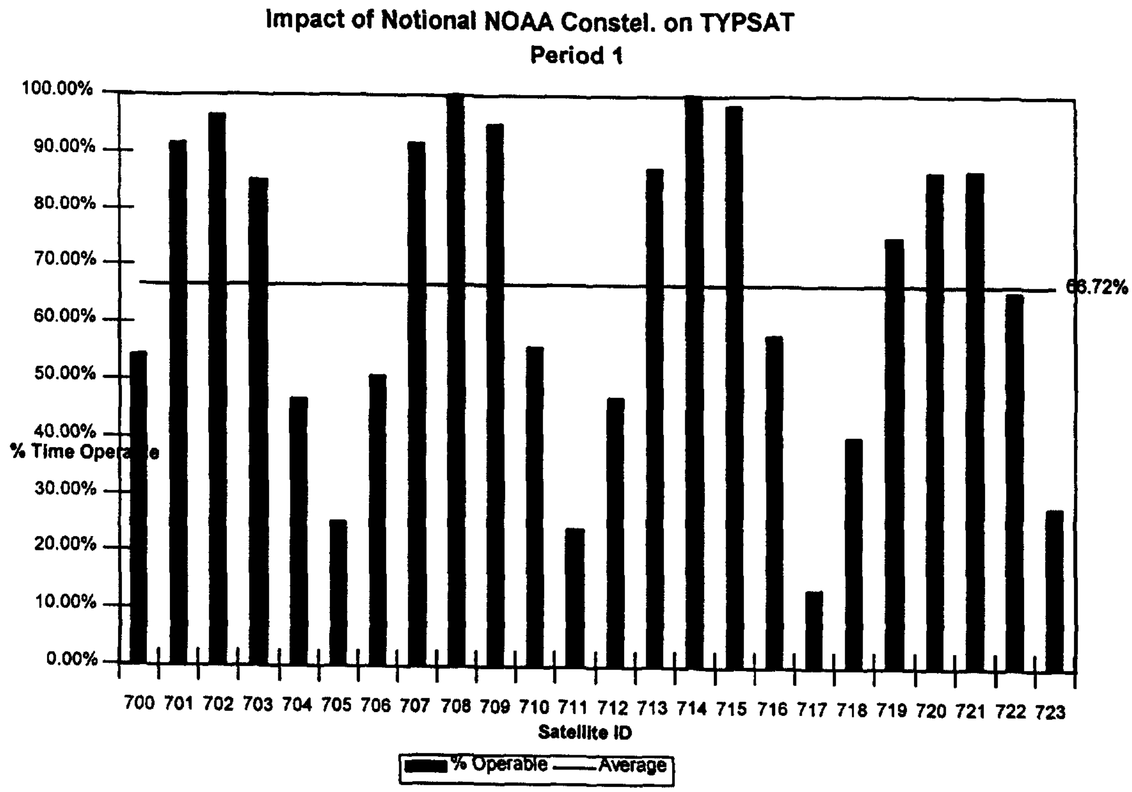
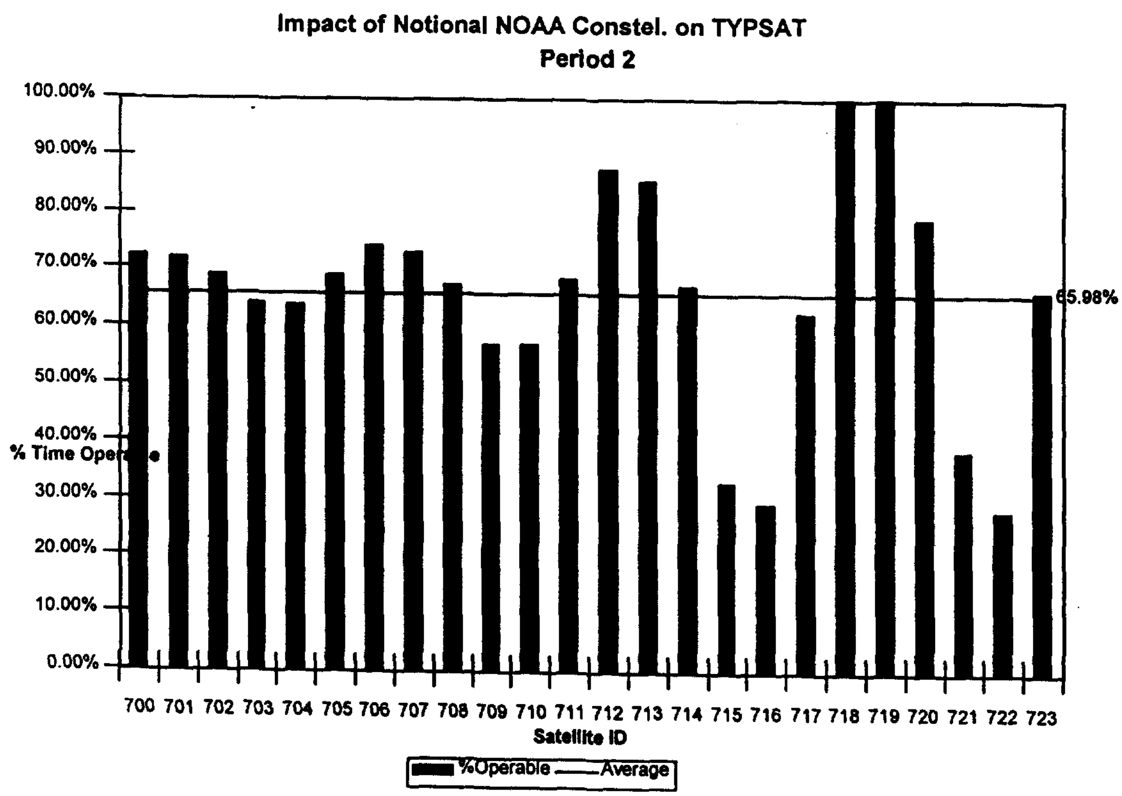


TYPSAT vs. NOAA

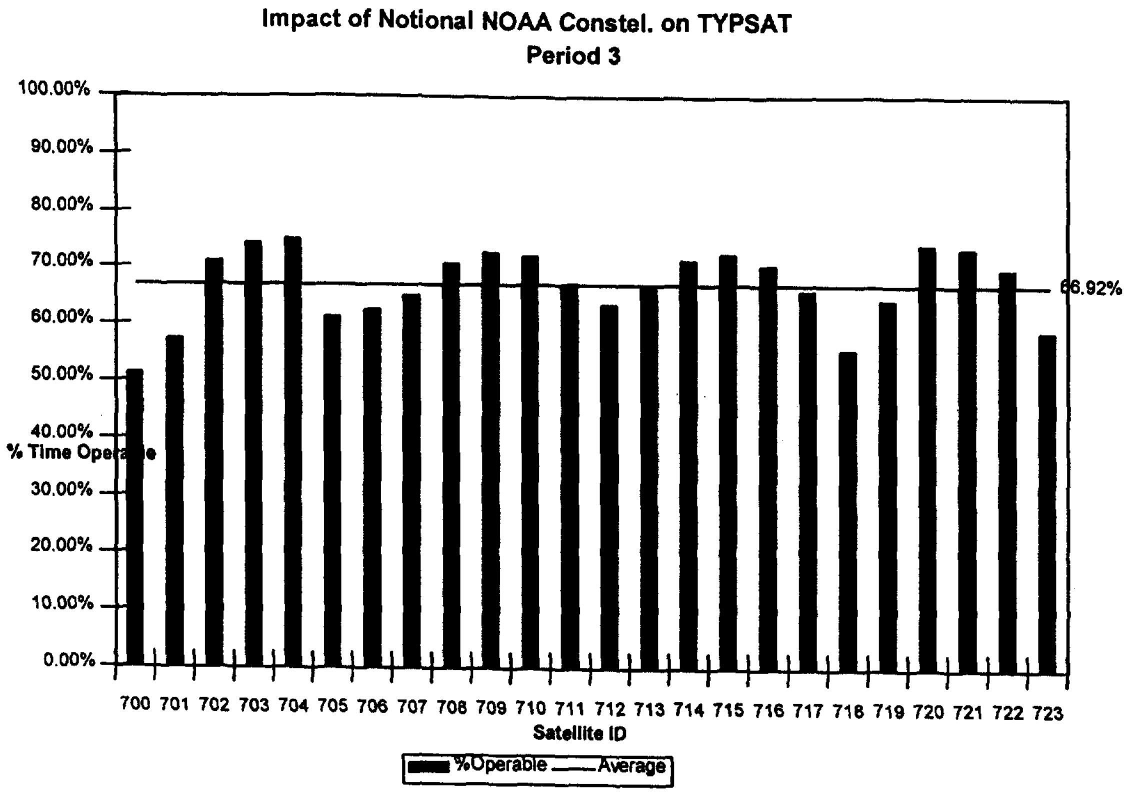
Again, Period 1 showed a greater impact, i.e. longer periods of interference, on fewer TYPSAT satellites than Period 3, which showed all nearly all TYPSATs impacted more uniformly. Periods 2 and 4 showed intermediate interactions. The average operation times for the TYPSAT constellation in each period were also more closely grouped than in the VITASAT-1R case. **Average operational time for the TYPSAT constellation across all four periods was 66.45%.**



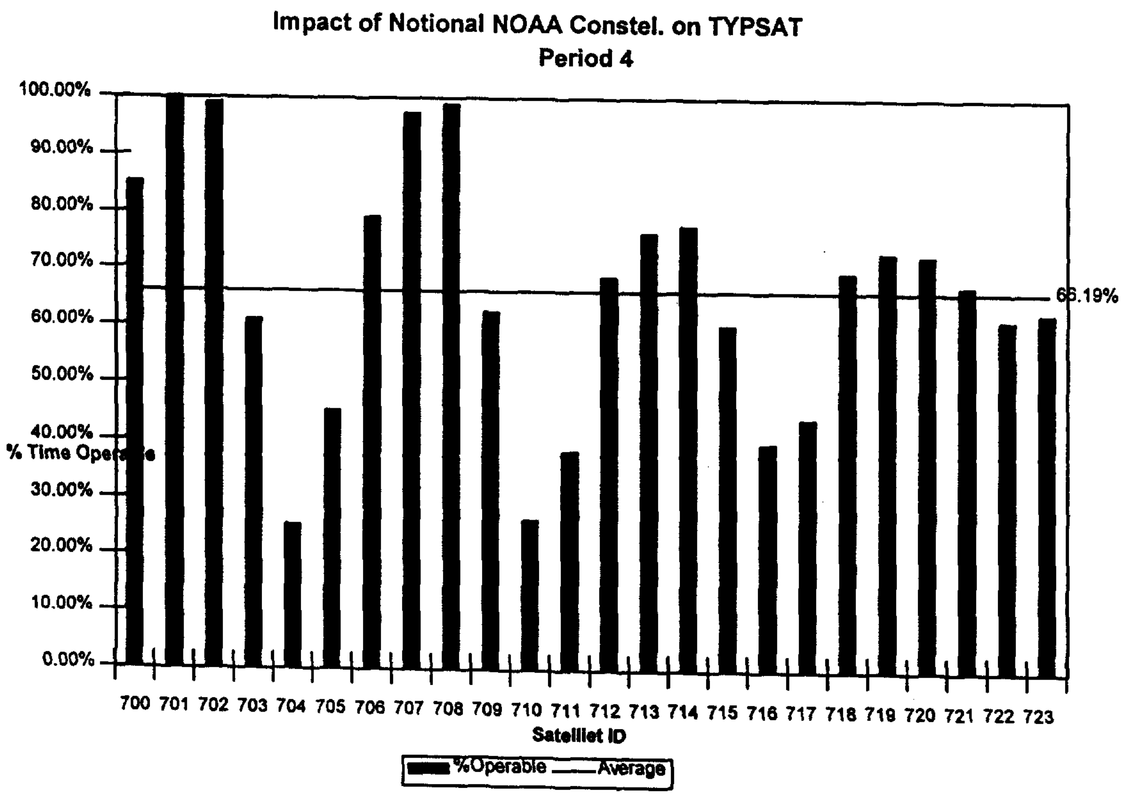
Impact of Notional NOAA Constel. on TYPSAT
Period 1
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
% Time Oper e
30.00%
20.00%
10.00%
0.00%
6.72%
700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723
Satellite ID
% Operable
Average



Impact of Notional NOAA Constel. on TYPSAT
Period 2
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
% Time Oper e
30.00%
20.00%
10.00%
0.00%
5.98%
700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723
Satellite ID
%Operable
Average



Impact of Notional NOAA Constel. on TYPSAT
Period 3
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
% Time Operable
30.00%
20.00%
10.00%
0.00%
66.92%
700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723
Satellite ID
%Operable
Average



Impact of Notional NOAA Constel. on TYPSAT
Period 4
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
% Time Operable
30.00%
20.00%
10.00%
0.00%
66.19%
700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723
Satelliet ID
%Operable
Average

ATTACHMENT B

ATTACHMENT B

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION
STUDY GROUPS

Document 8D/TEMP/128-E
5 November 1996
Original: English

Source: Document 8D/136

Sub-Working Group 8D3A-6

INFORMATION DOCUMENT IN SUPPORT OF CPM TEXT TO BE ATTACHED TO THE REPORT OF THE CHAIRMAN OF WP-8D

SPECTRUM DEMAND FOR NON-GSO MSS BELOW 1 GHz SERVICES

1 Introduction

In its considerings, Resolution 214 of WRC-95 "indicated that, in order to meet projected MSS requirements below 1 GHz, a range of an additional 7 to 10 MHz will be required in the near future." This information document summarizes the results of a study conducted to make more certain and more definitive future spectrum requirements for the MSS below 1 GHz.[1]

While any market assessment at such an early stage of development is uncertain, the demand scenarios constructed based on the study results suggest strong potential demand for NGSO MSS services. How much of this business potential is achieved will depend, among other factors, on the availability of sufficient spectrum worldwide to enable the development of these systems.

In addition to the study's market demand findings, this paper calculates the bandwidth for service links and feeder links that would be required to carry this traffic.

1.1 Scope

While there is broader potential for NGSO MSS satellite services, the scope of the study was concentrated on the following five application areas:

- Automated Meter Reading (AMR) for utilities industries
- Asset Tracking for the transportation and freight industries
- Vehicle Messaging for commercial vehicles and the trucking industry
- Personal Messaging for mobile individuals
- Remote Monitoring and Supervisory Control and Data Acquisition (SCADA) for oil and gas pipeline operators and individuals.

[1] *Business Opportunities in the Little LEO Satellite Services Market*; A Report Prepared for Final Analysis Communication Services Inc. by Deloitte & Touche, a major international consulting firm.

Analysis of the growth rates and drivers in the selected application areas was based on the seven-year time frame 1996-2002.

1.2 Methodology

Due to the early stage of development of NGSO MSS technology, the study relied heavily on in-person and telephone interviews to create the fact base. In all, more than 30 face-to-face interviews and more than 50 telephone interviews were conducted with three categories of people:

- End users in the target application areas
- Functional competitors and/or industry resellers (Big LEO service providers, terrestrial wireless communications providers)
- Industry observers (industry analysts in the financial community, industry consultants, journalists (trade) and equipment suppliers).

These created an up-to-date fact base, permitting less reliance on market reports or company brochures that might be outdated and/or set overly optimistic expectations for market demand or for end-use costs in adopting NGSO MSS satellite technology.

The interviews were supplemented by an extensive data-gathering effort based on secondary research sources - company documents, market research reports, and searches of trade journals.

In international markets for which data are not available, estimates were made based on benchmarks derived from known markets with similar economic, regulatory, and competitive environments.

1.3 Analysis

The overall market size was estimated based on the installed base of terminals in each application area. The growth rate applied was based on either historical growth trends or published growth projections. The addressable market size was based on an assessment of the NGSO MSS value proposition and its fit with end user technology selection criteria. To avoid "double-counting," the addressable market is an estimate of the number of users that could best be served via NGSO MSS technology. In each application area, alternative competitive technologies have been taken into account.

For each potential application area, the addressable market for NGSO MSS services is that portion of the total available market where NGSO MSS features and capabilities are likely to be more attractive than that of the substitute technologies, as perceived by end users and providers of substitute technologies.

The work performed by the study involved development of forward-looking demand scenarios based on interviews with industry participants and secondary data sources.

2 Addressable markets

The following information sets were developed for each market:

- Total market in units by year and region
- NGSO MSS addressable markets
- End-user technology selection criteria

- Assessment of functional substitutes
- NGSO MSS share of market
- Size of the NGSO MSS addressable market by year and by region.

For each market, the study assessed the ability of a variety of incumbent terrestrial and satellite-based wireless technologies to meet customer needs.

AUTOMATED METER READING

The number of utility meters was determined by taking the total installed base of conventional utility meters. In international markets for which data was not available, the study estimated the total number of meters based on benchmarks for the number of meters per capita for known markets with similar economic, regulatory and competitive environments. Next, seven-year projections were developed based on historical growth rates for the size of the installed base.

ASSET TRACKING

Estimates of the total number of commercial vehicles, cargo trailers and shipping containers were developed by determining the total installed base of commercial vehicles, cargo trailers and shipping containers in the world.

VEHICLE MESSAGING

Estimates for the total number of truck tractors, commercial vehicle and ships which could be equipped with messaging terminals were developed first by determining the total installed base of tractor trailers, commercial vehicles and ships in the world. In international markets for which data was unavailable, the total number of such vehicles was estimated based on benchmarks for the number of vehicles per capita for known markets with similar economic, regulatory and competitive environments. Growth projections were developed based on historical growth rates or, where available, industry projections for specific types of vehicles and ships.

PERSONAL MESSAGING

Estimates of the total number of personal messaging devices in North America and international markets are based on numerous industry data sources, including Mtel Corporation (Skytel), RAM Mobile Data, and Motorola.

SCADA

For SCADA, the study focused only on oil and gas providers. Determination of the total number of compressor-station SCADA remote terminal units was based on known data for a large number of oil and gas providers in North America, as well as an estimate for compressor-station remote terminal units based on North American benchmarks for the average number of remote terminal units per mile of pipeline. Industry sources relied on for data include the Oil and Gas Journal, as well as data published by the Petroleum Institute giving an overview of existing pipelines worldwide and projections for new pipeline construction and retirements over the next decade.

SUMMARY

The market study identified 42.9 million potential users for NGSO MSS services in the five application areas studied. Table 2-6 provides a summary of this projected market by area of application and regional use.

TABLE 2-6

Projected world market for NGSO MSS technology major application areas for the period 1996-2002

	North America	Europe	Latin America	Asia	Africa	Global Total
Automated Meter Reading	14,874	4,830	1,888	8,703	239	30,534
Remote Asset Tracking	844	296	77	N/A	N/A	>1,347
Vehicle Messaging	1,403	645	172	166	17	2,405
Personal Messaging	1,630	2,569	966	3,368	103	8,636
SCADA	12	8	2	6	1	29
Regional Total	18,763	8,348	3,105	>12,243	>360	>42,951

All numbers are in thousands.

N/A = not available.

2.2 Assessment of competitive technologies

To determine the addressable market for NGSO MSS services, functional requirements were identified for each application area, and then a variety of competitive, alternative terrestrial and satellite-based wireless technologies were identified and assessed as to their ability to meet the identified user needs.. The alternatives substitutes included in the study, and the requirements identified for each application are as follows:

Automated Meter Reading

Requirements: Low Cost per Read; Current Value-added Functionality; Compatibility with Existing Systems, Minimal Technology Risk; Prospect for Future Value-Added Capabilities; Rapid Installation and Deployment

Competitive Technologies: Manual (visual) reads, hand-held radio, mobile radio, fixed cellular networks

Asset Tracking

Requirements: Geographic Coverage and Flexibility; System Reliability; Low Operating Costs; Low System Costs; Rapid Updating

Competitive Technologies: GEO, cellular networks, specialized mobile radio data networks, Big LEO

Vehicle Messaging

Requirements:	Footprint of Coverage Area; Application Features and Functions; Near Real-time Connectivity; High Data-rate; Low Messaging and Terminal Costs; Small Terminal Size
Competitive Technologies:	GEO, cellular networks, specialized mobile radio data networks, Big LEO

Personal Messaging

Requirements:	Footprint of Coverage Area; Application Features and Functions; Near Real-time Connectivity; High Data Rate Capability; Low Messaging and Terminal Costs; Small Terminal Size
Competitive Technologies:	Specialized mobile radio data networks, cellular networks, GEO, Big LEO

SCADA

Requirements:	High Reliability and Redundancy; Real-time; Secure Communications; Capacity to Handle Peak Traffic; Ease of Integration; Speed to Deploy
Competitive Technologies:	Microwave, leased telephone circuits, GEO, fixed cellular networks

The market research studies, which resulted in the numbers of prospective users shown here for the five application areas for NGSO MSS services, took into account the cost and features the competing, alternative technologies listed above. Thus, the projected market shown in Tables 2-1 through 2-6 is the net market for NGSO MSS services. That is, these tables represent the overall number of prospective users for these services, after subtracting for those that would use competitive, alternative technologies.

3 Required bandwidth for NGSO MSS

For technical and economic reasons, this study is focused on frequency bands below 1 GHz for NGSO MSS service links. Using nearly omnidirectional gain patterns for the Mobile Earth Station (MES) antennas, the lower free-space propagation losses at VHF and UHF result in positive link margins using moderate transmitter powers (on the order of 5 - 10 W). These factors minimize the cost of MES and make them economically viable. However, the higher free-space losses at frequencies slightly above 1 GHz can be overcome for feeder links by using higher transmitter power and higher gain, narrow-beam tracking antennas at feeder link stations.

Some of the application areas summarized in Table 2-6 are primarily one-way. For example the bulk of the traffic on the service links for Automated Meter reading and remote tracking, will be from mobile earth stations to a satellite (i.e. service uplinks). In other application areas (e.g. Messaging) there will be more or less equal traffic on the service links in both directions between the satellite and mobile earth stations (i.e. on service uplinks and service downlinks). Similarly, traffic on feeder links will differ in the two directions of transmission. Therefore, spectrum requirements will be calculated separately for the four links between satellites and earth stations.

The first step in converting traffic demand into spectrum is to calculate the bandwidth that would be required in each of the four directions of transmission if that spectrum were to be used only by NGSO MSS systems. (This unlikely assumption is made only as a first step in calculation of the spectrum that would be required on a shared basis. All current MSS NGSO allocations are in bands shared with other services.)

Since all MSS NGSO spectrum will undoubtedly be shared with other services, the overall allocation to the several services in shared bands must obviously be larger than the spectrum required by any one of them. Thus, the spectrum required for MSS NGSO systems on an exclusive basis must be increased by a factor that will take into account the traffic requirements of other services; the requirement that NGSO MSS systems use only those channels within a shared band that will not cause interference to, or receive interference from, those other services; and the difficulty created by the wide range of domestic assignments made in shared bands by different countries around the world.

As discussed below, this study uses a multiplication factor of 5.0 to account for shared frequency usage, based on current terrestrial cellular experience.

However, even this multiplication factor of 5 does not take into account another aspect of the shared use of spectrum by systems providing global service that would increase the amount of spectrum that must be allocated to a service, above that dictated by the two shared-use factors discussed above. That is the wide difference in domestic allocations and assignments made by different countries around the world. For example, if 1 MHz were required for NVNG MSS, and a certain 5-MHz band were to be designated to be shared by it and other services on a worldwide basis, that particular 5-MHz band might be much more heavily used in some countries than others, or might be used in some countries by services that would make sharing difficult. That would result in NVNG MSS systems not being able to find enough non-interfering, and non-interfered-with channels in those countries. The solution would be to designate a wider band for sharing than the 5 MHz in the example above. The resulting use made by NVNG MSS systems in the larger band would still be only 1 MHz, but it would be a different 1 MHz in different countries.

3.1 Required bandwidth for NGSO MSS service uplinks

To estimate the total required uplink bandwidth, the following assumptions are made:

- The allocated frequency band will be used on a shared basis.
- The modulation type is GMSK, which results in a channel bandwidth 1.5 times the baud rate.[2]
- The average packet size is 128 bytes, or 1 024 bits, including overhead.
- Data transmission is uniformly distributed over the total available transmission time. (Several factors justify this conservative assumption. For one, typical NGSO satellites have footprints with a diameter of about 5 000 km, which encompasses three time zones. Therefore, traffic peaks during the Busy Hour will be spread out. Secondly, a major

[2] The multiplier of 1.5 for GMSK modulation is assumed only for the purpose of calculating required bandwidth for initial NVNG MSS systems, and is not meant to imply that modulation methods having greater efficiencies of bandwidth utilization will not be employed or required in future systems as usage increases. For example, in the United States, bandwidth efficiencies of 0.769 bits/Hz (that is, a multiplier of 1.3) are required now for terrestrial Land Mobile systems.

application of these systems, Automated Meter Reading, can be scheduled for transmission during off-peak hours, further reducing the peak-to-average factor.) Any adjustment factor introduced to account for non-uniform distribution of traffic would increase the required bandwidth over the estimates made here.

- Each user can see at least one satellite every time it transmits. More satellites in sight will not reduce the bandwidth requirements, since it is assumed that the bandwidth will be shared by all satellite systems to provide service to all users. If coverage is not continuous, the required bandwidth would have to be increased, since the same number of packets would have to be transmitted in less time.
- To account for repeats of incomplete or missed transmissions, an adjustment factor of 1.35 is used.
- To account for shared frequency usage - that is, if the band will be shared with other services that will take up some of the capacity and that must be protected from interference - the shared band must be wider than that required to carry only the MSS traffic. An adjustment factor of 5 is used in this analysis, based on current terrestrial cellular experience. Assume that in a 4-MHz bandwidth, 8 000 existing terrestrial users are within interference range of a mobile earth station (MES). Assume further that each such existing user transmits for 6 minutes during an 8-hour period each day. The total traffic generated by these users would be:

$$\frac{(8\,000 \times 6)}{(8 \times 60)} = 100 \text{ Erlangs,}$$

which corresponds to 128 trunks (channels) being utilized with a grade of service of P = 0.001.[3] Now, if the 4-MHz total bandwidth is divided into 160 channels of 25 kHz each, then 32 channels (160 - 128) would be available for use by MSS. That is one-fifth, or 20% percent, of the total number of 160 channels. This means that for an MSS allocation to be shared with existing users having the usage pattern assumed here, the allocation would need to be five times that of an exclusive allocation. Hence, a multiplication factor of 5 is used in the calculation of required bandwidth to account for sharing with existing terrestrial users[4].

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[3] The grade of service is the ratio of the number of calls that are not completed at first attempt, to the total number of attempts to establish a connection during a specific period of time, usually the Busy Hour.

[4] Recent tests made on an operational NVNG MSS satellite equipped with DCAAS revealed that within a footprint covering all of the United States and portions of Canada and Mexico, between 150 to 200 2.5 kHz interstitial channels out of a total of 800 channels in the 148 MHz band appeared to be unused by terrestrial mobile users for varying lengths of time (with a mean duration of about 20 seconds). That would indicate a multiplication factor of between 4 and 5 for shared use. In more heavily used bands the multiplication factor for shared used might be considerably higher.

Using these assumptions, the required channel capacity is calculated from the following equation:

$$\text{Channel Capacity} = \frac{(\text{Num of users}) \times (\text{Num of packets/day/user}) \times (1\,024 \text{ bits/packet})}{\text{Total Transmission Time}} \text{ Bits/Second}$$

Where:

Total Transmission Time = (24 Hours/Day) x (60 Minutes/Hour) x (60 Seconds/Minute) = 86400 Seconds/Day

Table 3-1 shows the required channel capacity for each service category based on the projected number of users for all regions. There may be other projections based on different assumptions that would increase the required channel capacity. In this regard, the following is a conservative estimate.

TABLE 3-1

Channel capacity requirements

		North America		Europe		Latin America		Asia		Africa	
	Packets/ Day User	Users (kb/s)	Channel capacity	Users (kb/s)	Channel capacity	Users (kb/s)	Channel capacity	Users (kb/s)	Channel capacity	Users (kb/s)	Channel capacity
Automated Mtr. Reading	1	14,874,000	176.28	4,830,000	57.24	1,888,000	22.38	8,703,000	103.47	239,000	2.83
Remote Tracking	48	844,000	480.14	296,000	168.40	77,000	43.80	N/A	N/A	N/A	N/A
Vehicle Messaging	4	1,403,000	66.51	645,000	30.58	172,000	8.15	166,000	7.87	17,000	0.81
Personal Messaging	32	1,630,000	618.19	2,569,000	974.32	966,000	366.36	3,368,000	1277.35	103,000	39.03
SCADA	N/A	N/A		N/A		N/A		N/A		N/A	
Total			1341.12		1230.54		440.69		1388.69		42.67

N/A = not available at this time.

The largest capacity total for each region determines the channel capacity requirement. Although Asia has the highest estimate for channel capacity, the entire region cannot be covered by one footprint. In order to calculate the required bandwidth for Little LEO systems, it is necessary to consider a region that has the required channel capacity and at the same time is covered by one footprint. Since the required channel capacity for North America is comparable to that of Asia, and North America is covered by one footprint, the required channel capacity for North America has been used to calculate the required bandwidth for Little LEO systems. Thus assuming GMSK modulation and a multiplication factor of 1.35 to account for incomplete or missed transmissions, the total required uplink bandwidth is:

$$\text{Bandwidth}_{\text{exclusive}} = 1341.12 \times 1.5 \times 1.35 \text{ » } 2.72 \text{ MHz}$$

This bandwidth must be increased by the factor of 5 if it is shared with other services:

$$\text{Bandwidth}_{shared} = 2.72 \times 5 = 13.6 \text{ MHz.}$$

Therefore, 13.6 MHz of bandwidth is the minimum required for uplinks on a shared basis.[5]

3.2 Required bandwidth for NGSO MSS service downlinks

To estimate the total required bandwidth for NGSO MSS downlinks below 1 GHz, the following assumptions are made:

- The data received for Vehicle Messaging and Personal Messaging will be transmitted via service downlink.
- Automated Meter Reading and Remote Asset Tracking do not require service downlinks.
- Each user can see at least one satellite every time it transmits or receives. More satellites in sight will not reduce the bandwidth requirements, since the bandwidth will be shared by all satellite systems.
- The allocated frequency band will be used on a shared basis, using coordination and Exclusion Zone methods.
- The modulation is GMSK, which results in a channel bandwidth 1.5 times the baud rate[2].
- To account for repeats of incomplete or missed transmissions, an adjustment factor of 1.35 is used.
- To account for shared frequency use, a multiplication factor of 5 is used. (See discussion in Section 3.1.)
- Downlink channel capacity needed for polling or frequency assignment to frequency-agile terminals is negligible compared to the channel capacity needed for uplink transmissions. (Downlink polling and frequency assignment will need a maximum of only 12 bytes per terminal, compared with a minimum uplink data length of 128 bytes for subscriber-generated information.)

Using these assumptions, the required channel capacity and bandwidth for service downlinks based on the projected number of users would be as follows:

$$\text{Channel Capacity} = 618.19 + 66.51 = 684.7 \text{ kb/s}$$

Therefore, the total bandwidth required for service downlinks on an exclusive basis is

$$\text{Bandwidth}_{exclusive} = 684.7 \times 1.5 \times 1.35 = 1.4 \text{ MHz}$$

And the shared bandwidth requirement is

$$\text{Bandwidth}_{shared} = 1.4 \times 5 = 7 \text{ MHz.}$$

This calculation is made for North America; Asia may require twice as much bandwidth, since the projected demand for messaging in Asia is twice that for North America.

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[5] The additional bandwidth for uplinks will be this total minus the spectrum now available for NGSO MSS uplinks.

3.3 Required bandwidth for NGSO MSS feeder-links

To estimate the total required bandwidth for NGSO MSS feeder links above 1 GHz, the following assumptions are made:

- The data received from Automated Meter Reading at the satellite will be sent to the ground station via the feeder downlink.
- The data received from Remote Asset Tracking at the satellite will be sent to the ground station via the feeder downlink.
- The data for Vehicle Messaging and Personal Messaging may have to utilize either feeder uplink or feeder downlink. In order to calculate the required channel capacity, both cases are considered.
- Each user can see at least one satellite every time it transmits or receives. More satellites in sight will not reduce the bandwidth requirements, since it is assumed that the bandwidth will be shared by all satellite systems to provide service to all users.
- The allocated frequency band will be used on a shared basis through the use of local coordination and exclusion zone methods. Therefore, no sharing factor need be used in the calculation of the required bandwidth for feeder links.
- Coordination and geographic separation of Earth stations can make the entire allocated bandwidth available to each satellite system.
- The modulation is GMSK, which results in a channel bandwidth 1.5 times the baud rate. The rapid roll-off of GMSK signals outside the occupied bandwidth facilitates sharing among satellite systems and with fixed services. This is particularly important for frequency bands near those allocated to the Radio Astronomy Service, which can only tolerate extremely low interference (-255 dBW/m^2/Hz).
- To account for repeats of incomplete or missed transmissions, an adjustment factor of 1.35 is used.
- Channel capacity needed for Telecommand, Telemetry and Control (TT&C) will be negligible compared to the channel capacity needed for transmission of subscriber-generated information.

Using these assumptions, the required channel capacity and bandwidth for feeder links based on the projected number of users would be:

Feeder Uplink:

Channel Capacity = 618.19 + 66.51 = 684.7 kb/s,

Required Bandwidth = 684.7 x 1.5 x 1.35 = 1.4 MHz

Feeder Downlink:

Channel Capacity = 176.28 + 480.14 + 66.51 + 618.19 = 1341.12 kb/s

Required Bandwidth = 1341.12 x 1.35 x 1.5 = 2.7 MHz

Therefore, the total bandwidth required for feeder links is 1.4 + 2.7 = 4.1 MHz.

4 Conclusion

Based on market studies of the demand for NGSO MSS services, and reasonable assumptions for calculating the spectrum required to transmit that traffic, a minimum of 20.6 MHz of bandwidth shared with other services will be required for service links in both directions of transmission, and 4.1 MHz for feeder links in both directions, as shown in Table 4-1. To determine the additional spectrum required, the existing primary allocation of approximately 3.5 MHz must be subtracted from the total required spectrum of 24.7 MHz. This leaves an additional requirement of about 21 MHz.

TABLE 4-1

Bandwidth required for NGSO MSS service and feeder links

	Bandwidth Required (MHz) **If Exclusive**	**Bandwidth Required (MHz)** **If Shared***
Service Uplinks	2.72	13.6
Service Downlinks	1.4	7.0
Service Link Total:	**4.12**	**20.6**
Feeder Uplinks		1.4
Feeder Downlinks		2.7
Feeder Link Total:		**4.1**
*NOTE - The bandwidth of allocations must be wider than the shared bandwidths shown in this column, as discussed in Section 3, above.		

TABLE 2

Required bandwidth

	Bandwidth Required (MHz) , **If Exclusive**	**Bandwidth Required (MHz),** **If Shared ***
Service Uplinks	2.72	13.6
Service Downlinks	1.4	7.0
Service Link Total:	**4.12**	**20.6**
Feeder Uplinks		1.4
Feeder Downlinks		2.7
Feeder Link Total:		**4.1**
*NOTE - The bandwidth of allocations must be wider than the shared bandwidths shown in this column because of the differences in domestic allocations, and the extent of their use in different parts of the world.		

The MSS allocation requirements include both service and feeder links (which usually operate within the service bands). In general, the inbound and outbound allocations should be approximately balanced for CDMA systems. A wider uplink allocation, however, leads to a more benign sharing situation; the wideband MSS system can operate with a lower power density by spreading over wider bandwidths. One system, with FDMA uplinks and TDMA downlinks requires approximately five times the downlink bandwidth as uplink bandwidth. Narrow band MSS systems with dynamic channel selection will occupy any given subchannel less often and will require a greater bandwidth to achieve a given message rate. Thus, the uplink and downlink allocations do not necessarily have to be equal. Note that the current studies show that on a worldwide basis an average of 3.2 million non-GSO MSS users would be provided service in each 1 MHz of bandwidth for uplinks and 6.1 million users per MHz for downlinks, when the data rates and frequency of use among the various users are taken into account.

In view of the requirements just noted, there is unlikely to be sufficient spectrum available beginning in the year 2000 to accommodate the requirements of the MSS Below 1 GHz service. For systems planned to be implemented around the year 2000 and later, there does not currently appear to be sufficient worldwide access in the available bands for such systems to grow and achieve commercial viability. Given the time required to develop and construct satellite systems, an additional 21 MHz (24.7 MHz minus the existing 3.5 MHz) on a worldwide basis is required in the immediate future if the requirements for the non-GSO MSS below 1 GHz are to be met.

EXHIBIT 3

SPECTRUM SHARING PROPOSALS

FINAL ANALYSIS COMMUNICATION SERVICES, INC.

I. INTRODUCTION

Final Analysis Communication Services, Inc. ("Final Analysis") has prepared proposals for three alternative band plans. All three of these alternative band plans would avoid mutual exclusivity and accommodate qualified second round applicants on an interim basis. Furthermore, two of the alternative band plans provide four fungible systems. The third alternative band plan would accommodate the varying requirements of second round Little LEO applicants.

The alternative proposals suggest a realignment of the Commission's proposed band pairings. These proposals would split the available downlink bands and avoid the inherent mutual exclusivity problems. Furthermore, they rely on WARC-92 allocated Spectrum. Should the Commission decide to make the WRC-95 allocated spectrum available at this time, then an option exists to augment the suggested uplink spectrum for Alternative Proposals 1, 2, or 3 with WRC-95 spectrum.

In addition, Final Analysis has suggested a virtual constellation concept in earlier presentations to the Commission. In our view, the virtual constellation is still a viable interim solution for provisioning a coordinated service to the marketplace, provided that all qualified second round applicants would agree on a coordinated deployment and operational procedure for the virtual constellation.

II. ALTERNATIVE PROPOSAL 1 - FOUR ESSENTIALLY EQUAL SYSTEMS

Alternative Proposal 1 would be enable the Commission to license each of four qualified second round applicant with separate and fungible spectrum, thus avoiding the issue of mutual exclusivity.

Alternative Proposal 1 identifies eight separate spectrum segments: four downlinks and four uplinks. These uplink/downlink segments can be put together in any combination. The pairings may be chosen by the Commission or proposed by the qualified second round applicants. Essentially, they should be treated as fungible, as was the case with DBS service with respect to the available eastern and western orbital locations.

Should this proposal be accepted, resulting in license awards in separate band segments to the four qualified second round applicants, nothing should prevent the licensees from being able to voluntarily share their bands with other licensees.

Downlink - Downlink spectrum is identified by dividing each of the 137.0-138.0 MHz and 400.15-401.0 MHz bands into two systems (see attached figures).

PS1-1D:	137.025-137.175 MHz (note 1) 137.333-137.367 MHz (note 2) 137.485-137.515 MHz (notes 2 & 3) 137.605-137.635 MHz (notes 2 & 3)
PS1-2D:	137.753-137.787 MHz (note 2) 137.825-138.0 MHz (note 1)
PS1-3D:	400.1500-400.3275 MHz 400.6450-400.8225 MHz (note 4)
PS1-4D:	400.3275-400.5050 MHz 400.8225-401.000 MHz

Note 1: These bands can be used primary until 2002. After 2002, these bands can be time shared with EUMETSAT and NOAA METSTAT.

Note 2: These channels can be used as secondary until January 2000, co-primary afterwards.

Note 3: Orbcomm might migrate some of its operation into these channels when NOAA begins operation in the 137.025-137.175 MHz sub-band, no sooner than 2003.

Note 4: These systems must be able to change frequency from one of the two proposed channels (per system) to the other channel (of the same system).

Uplink - Alternative Proposal 1 suggests four systems utilizing only the WARC 92 spectrum. In this proposal, we have considered one spread spectrum (CDMA or wide band) system and three FDMA/TDMA systems (see attached figures).

PS1-1U	149.905-149.900 MHz This is a CDMA system. As an alternative, if acceptable by the Commission, we propose to move this band to 148.025-148.905 MHz.
PS1-2U	148.905-149.305 MHz This is a FDMA/TDMA system (total of 400 kHz shared with Orbcomm).
PS1-3U	149.305-149.585 MHz, and 149.635-149.755 MHz This is a FDMA/TDMA system (total of 400 kHz shared with Orbcomm).

PS1-4U 149.755-149.900 MHz, and 149.950-150.050 MHz
This is a FDMA/TDMA system (55 kHz shared with Orbcomm, 90 kHz shared with VITA, and 100 kHz non-shared).

III. ALTERNATIVE PROPOSAL 2 - FOUR CUSTOMIZED SYSTEMS

Alternative Proposal 2 is similar to Alternative Proposal 1 in its approach to the uplink spectrum. However, Alternative Proposal 2 offers a different approach to the downlink spectrum, differentiating among qualified second round applicants as to their market focus. Some applicants do not require as much downlink as others because of their planned service applications.

Alternative Proposal 2 would maximize spectrum efficiency by customizing the allocations to the market requirements of the qualified second round applicants. An additional benefit of this proposal would be achieved primarily by ensuring that DoD frequency modification restrictions affect only the ground stations and would not require costly modifications to subscriber terminals.

Downlinks (see attached figures):

PS2-1D 137.025-137.135 MHz (note 1)
137.333-137.367 MHz (note 2)
137.485-137.515 MHz (notes 2&3)
137.605-137.635 MHz (notes 2&3)
137.865-138.000 MHz (note 1)

PS2-2D 137.135-137.157 MHz (note 1)
137.753-137.787 MHz (note 2)
137.825-137.865 MHz (note 1)

PS2-3D 400.150-400.505 MHz
400.645-401 MHz (note 4)

PS2-4D 400.505-400.5517 MHz (note 5)

Note 1: These bands can be used primary until 2002. After 2002, these bands can be time shared with EUMETSAT and NOAA METSAT.

Note 2: These channels can be used as secondary until January 2000, co-primary afterwards.

Note 3: Orbcomm might migrate some of its operation into these channels when NOAA begins operation in the 137.025-137.175 MHz sub-band, no sooner than 2003.

Note 4: These systems must be able to change frequency from one of the two proposed channels (per system) to the other channel (of the same system).

Note 5: This system will share its downlink with VITA.

Uplinks (see attached figures):
The uplink segments proposed in this Alternative are the same as those proposed for Alternative Proposal 1.

PS2-1U 148.149.900 MHz
This is a CDMA system. As an alternative, if acceptable by the Commission, we propose to move this bad to 148.025-148.905 MHz.

PS2-2U 148.905-149.305 MHz
This is a FDMA/TDMA system (total of 400 kHz shared with Orbcomm).

PS2-3U 149.305-149.585 MHz, and 149.635-149.755 MHz.
This is a FDMA/TDMA system (total of 400 kHz shared with Orbcomm).

PS2-4U 149.755-149.900 MHz, and 149.950-150.050 MHz
This is a FDMA/TDMA system (55 kHz shared with Orbcomm, 90 kHz shared with VITA, and 100 kHz non-shared).

IV. ALTERNATIVE PROPOSAL 3 - BAND SHARING SYSTEMS

Under Alternative Proposal 3, each of the qualified second round applicants would be granted a separate license for the entire band. The licensees would be assigned the same downlink and uplink spectrum subject to band sharing criteria to be coordinated by licensees once the Commission has authorized this approach. Close coordination among the licensees is assumed in this proposal.

The band sharing solution offered in Alternative Proposal 3 differs form the virtual constellation concept in that this solution does not require sharing of spacecraft platforms and/or launch vehicles. This solution would ensure against spectrum warehousing under a "use it or lose it" dictum.

Alterative Proposal 3 provides an enhanced and efficient use of the spectrum, particularly by ensuring that the DoD requirement of changing the frequency of the satellite and ground station(s) within 90 minutes would affect only gateways and not the user terminals.

<u>Service Links</u> **(to/from terminals):**

Downlink	137-025-137.175 MHz (note 1) 137.333-137.367 MHz (note 2) 137-485-137.515 MHz (notes 2 & 3) 137.605-137.635 MHz (notes 2 & 3) 137.753-137.787 MHz (note 2) 137.825-138.0 MHz (note 1)

Note 1: These bands can be used primary until 2002. After 2002, these bands can be time shared with EUMETSAT and NOAA METSAT.

Note 2: These channels can be used as secondary until January 2000, co-primary afterwards.

Note 3: Orbcomm might migrate some of its operation into these channels when NOAA begins operation in the 137.025-137.175 MHz sub-band, no sooner than 2003.

Uplink: 148.905-149.9 MHz

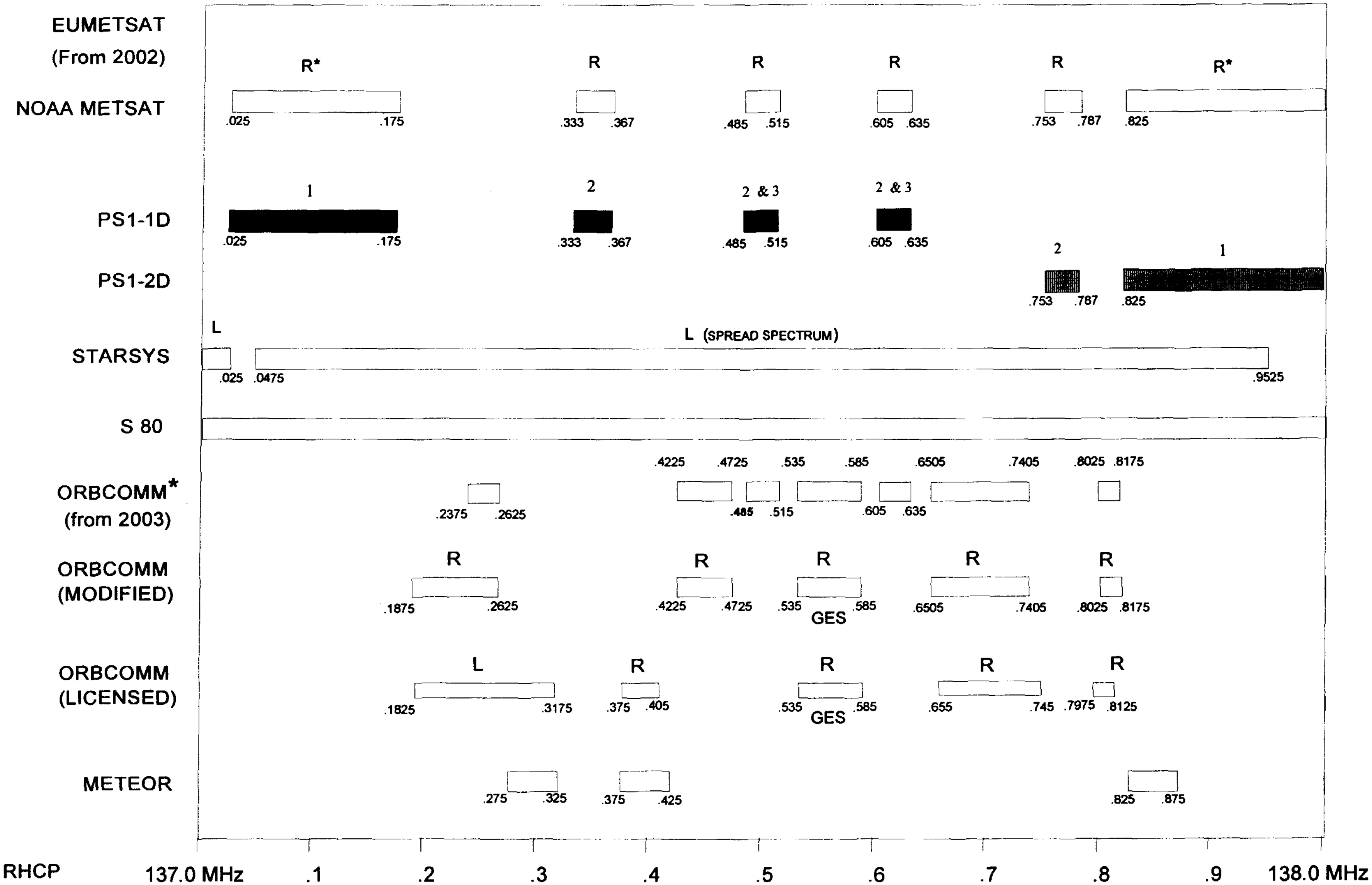
<u>Feeder Links</u> **(to/from gateways):**

Downlink:	400.1500-400.5050 MHz 400.6450-401.0000 MHz

Uplink: 149.95-150.05 MHz

Final Analysis Alternative Proposal 1

137.0 - 138.0 MHz Downlink Band



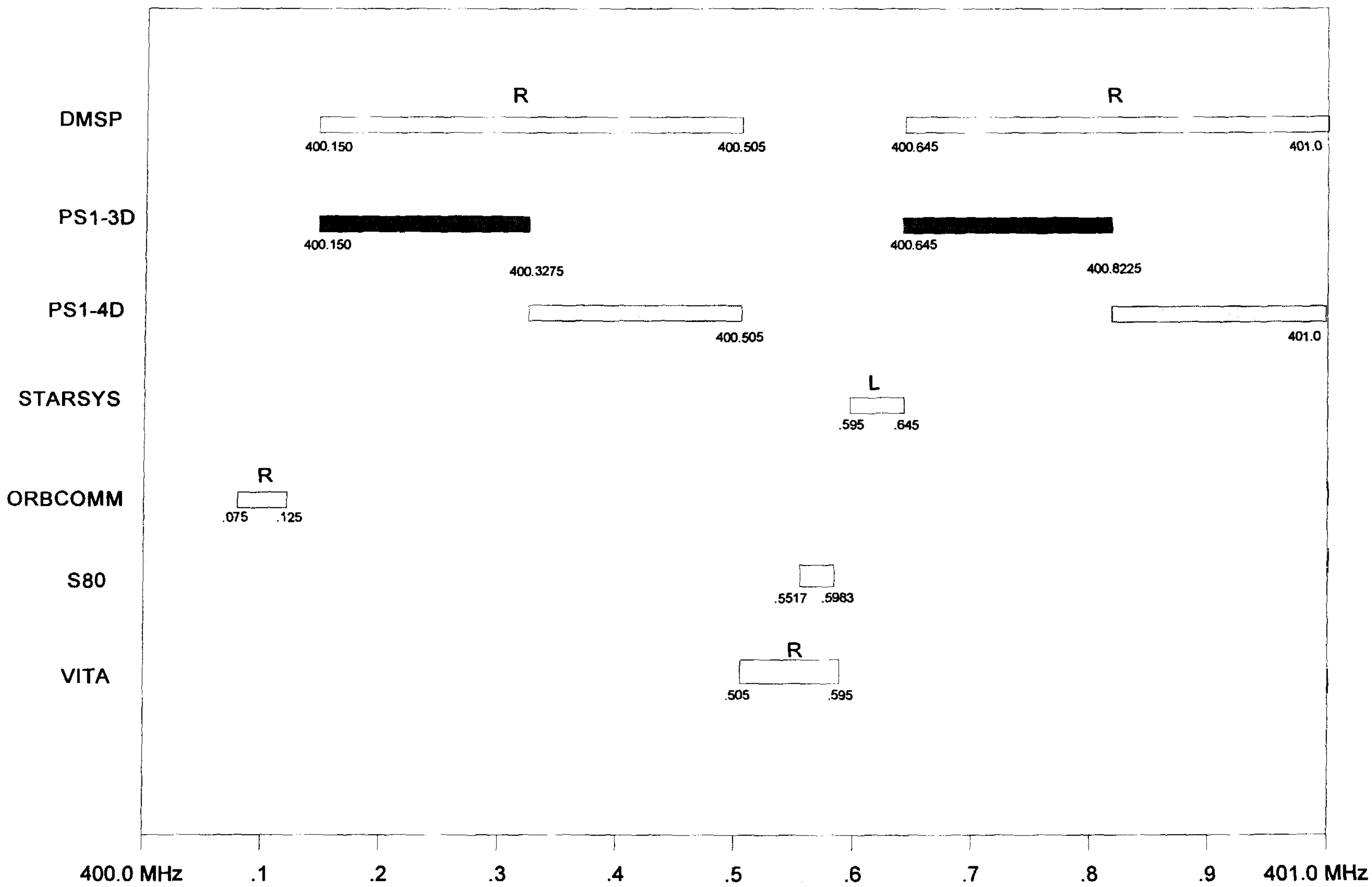
R: RHCP
L: LHCP

*. Effective 2003, NOAA will begin using the Subband (one satellite in 2003, and second satellite in 2007) and Orbcomm will have to migrate its channels from 0.185-0.2375 to two of NOAA's channels

1. These bands can be used primary till 2002, time share with NOAA afterwards
2. These channels can be used as secondary unite January 2000, co-primary afterwards
3. Orbcomm might migrate some of it's operation into these channels when NOAA begins operation in the 137.025-137.175 sub-band, no sooner than 2003

Drwfile\137nprm_fai1.drw121796

Final Analysis Alternative proposal 1
400.0 - 401.0 MHz Downlink Band



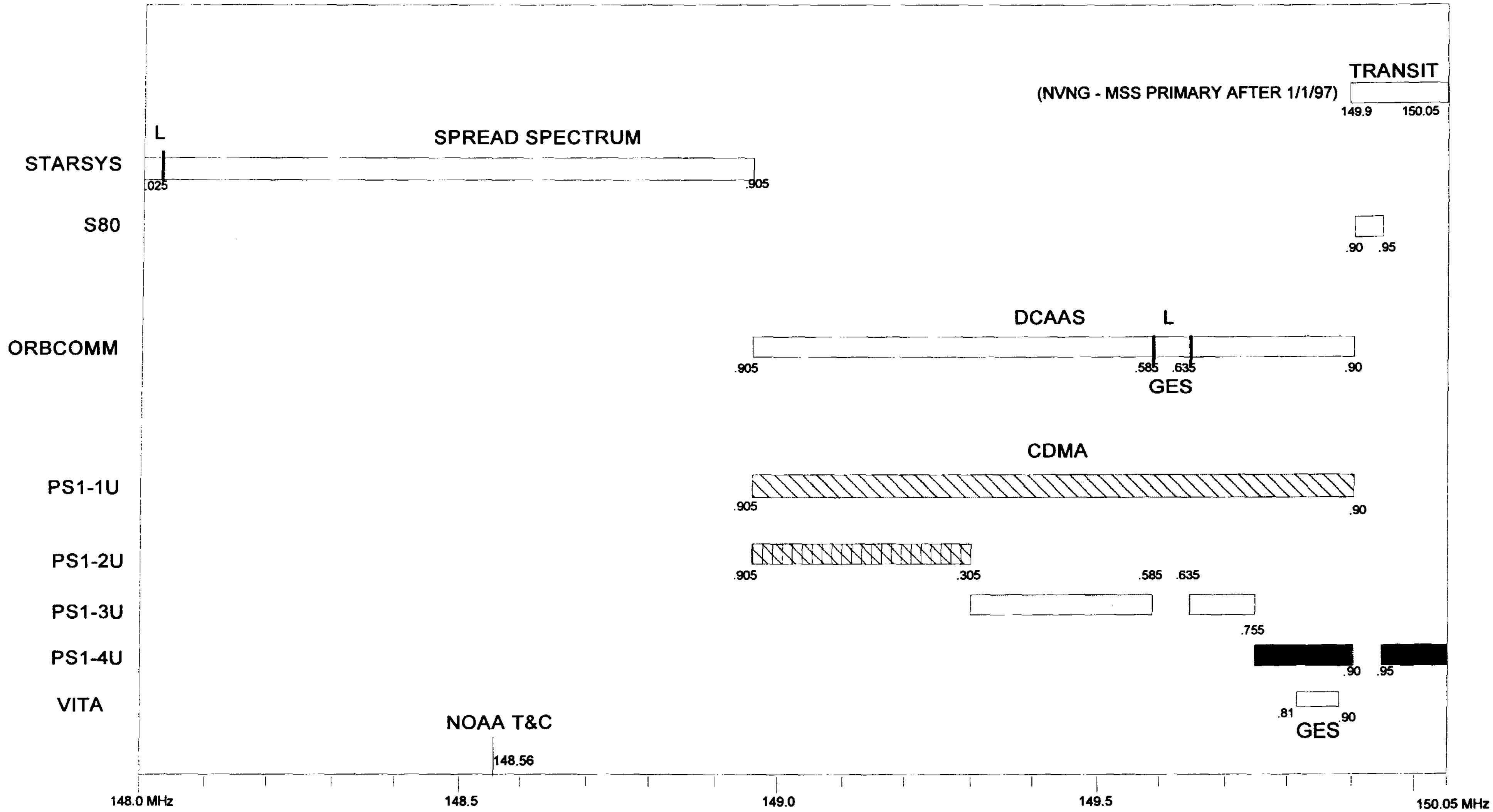
R: RHCP
L: LHCP

4. these systems must be able to change frequency from one of two proposed channels (per system) to the other channel (of the same system)

Drwfile\400mnrp_fai1-121796

Final Analysis Alternative Proposal 1 or 2

148.0 - 150.05 MHz Uplink Band



R: RHCP
L: LHCP

Drwfile\148nprm-fai.121996